EFFECT OF ALOMAE-BOBONE VIRUS COMPLEX ON YOUNG TARO SEEDLINGS AND OTHER AROID SPECIES IN CONTROLLED CONDITIONS

ANTON IVANCIC, RUTH LILOQULA[1], HELEN LEVELA[2] AND JIMI SAELEA[3]

Plant Breeder and Geneticist, Ministry of Agriculture and Lands
Dodo Creek Research Station, P. O. Box G13, Honiara, Solomon Islands

Abstract

The effect of Alomae-Bobone Virus Complex (ABVC), the lethal disease of taro *Colocasia esculenta* in the Solomon Islands, on young taro seedlings and on other aroid species has been studied. Young taro seedlings are very sensitive to the disease. The symptoms of the disease are not uniform. Other aroid species can also be affected by ABVC in controlled conditions.

Introduction

The Alomae-Bobone Virus Complex (ABVC) is a lethal disease of taro (*Colocasia esculenta*). This disease together with the taro beetle (*Papuana* spp.) represent the major limiting factors in taro production in the Solomon Islands. The ABVC is very severe in Malaita, Santa Isabel, San Cristobal, Choiseul, and North New Georgia.

There were several attempts to solve the problem of ABVC by breeding for genetic resistance. The analysis of the existing cultivars showed that there was no resistance. A certain level of tolerance existed only in female taros.

The disease was studied and described by several authors: James et al. (1973), Kenton and Woods (1973), Gollifer et al. (1975), Jackson and Gollifer (1975), Gollifer et al. (1977), and Gollifer et al. (1978).

At first ABVC was considered as two separate viral diseases: Alomae and Bobone. Taro leafhoppers were considered as the main vectors of the disease spread.

Kenton and Woods (1973) distinguished two types of bacilliform virus particles causing the ABVC disease. The larger was of the rhabdovirus type, and the smaller had a shape and size similar to the West African Cocoa Swollen Shoot Virus and to the bacilliform particle observed in *Dioscorea alata.*

The diseased tissue was studied with an electron microscope, and it was found that the large particle was present in plants showing Bobone symptoms and both particles in plant tissue of Alomae-affected plants. Occasionally Dasheen Mosaic Virus particles were also present.

The symptoms usually differ depending on plant type (male-female). The terms male and female as used here have no connection with the sex expression of the taro plants. Female taros are smaller, low yielding with many suckers, and tolerant to Alomae. Usually they show only the symptoms of Bobone. Male taros are high yielding and are bigger plants but are susceptible to Alomae and die from it. The symptoms observed on fully developed plants were similar to those described in the literature.

Because of the importance of ABVC, the occurrence of viral particles was studied in other aroid species: *Xanthosoma, Alocasia, Cyrtosperma* (Gollifer et al. 1977). It was found that virus particles can also appear in other aroids. Similar but more dramatic results were found for dasheen mosaic virus by Zettler (1986).

The main purpose of this study was to find out the effect of ABVC on young seedlings and other aroid species in controlled conditions and to create resistant or tolerant genotypes to all major diseases. If the effects of ABVC on taro seedlings are similar to those on mature plants, then the expensive field testing of thousands of seedlings can be accomplished by the elimination of the majority of seedlings that are not resistant to ABVC in early stages. It would also be useful to find some other aroid species that are closely related to taros and that are resistant, tolerant, or immune to the viral disease and to use them in interspecific or intergeneric crosses.

Materials and Methods

The Solomon Islands taro breeding program is based on a population improvement recurrent selection method. Several plant characteristics have to be improved at the same time: resistance to diseases (ABVC, *Phytophthora,* and *Mitimiti*), yield, quality, and adaptability to a wide range of farming and social systems.

The testing of the plants for resistance under field conditions is very expensive and time consuming. The results are strongly affected by environmental stress conditions (drought and taro beetle attack), which modify the real results of the test.

Testing of Young Seedlings for Resistance

The experiment included nine different hybrids belonging to the groups of most interest for ABVC breeding. There were nine replications, each one in a separate cage (80 x 80 x 60 cm) covered with insect-proof netting. Each hybrid was planted in a separate medium-size pot (ten plants per pot). Infected virus source plants were planted in two pots; a pot with the bigger plant in the center of the cage and a pot with three smaller Bobone-affected plants were placed randomly among pots with seedlings.

The hybrids included in the experiment were:

1. 182E x 35
2. 85-6 x 95-10
3. 91 -4 x 85
4. 70-10 x 85
5. Wild Bangkok taro x 90-4
6. 77-4 x 84
7. 85-5 x 190-1
8. 22-5 x 10-4
9. 69-2 x 93

The testing started on March 3, 1992. Everyday during the first two weeks the pots were rearranged inside each cage and the sources of Bobone were randomly taken from one cage to another. The main reason for this randomization was the possibility that the virus particles had genetic variation. The other reason was the concentration of the virus particles and their relation to the number of vectors. The plants used for this test were in the fifth leaf growth stage.

The first Bobone symptoms appeared ten days after the beginning of the test.

The vectors were acting differently. The taro leafhoppers *(Tarophagus proserpina)* remained on adult plants with Bobone symptoms for about two weeks. When the adult plants started to wilt because of the disease and high concentration of insects, they moved on to young seedlings.

The aphids infested the seedlings immediately, and they probably transferred the first virus particles. One month after infestation (on April 4, 1992), the plants were sprayed with Malathion to kill the insects.

Testing Other Aroid Species

Interspecific and intergenetic crosses might be important for taro breeding in the near future. The crosses between *Colocasia esculenta* and *Colocasia gigantea* are probably the most common thus far.

For the Solomon Islands, it is important to find out if there is any possibility of transferring the resistance, tolerance, or immunity to ABVC from other aroid species to *Colocasia esculenta.*

In a systematic experiment in nine cages (nine replications), several aroid species were tested for ABVC resistance together with Colocasia esculenta. The vectors were aphids (green and brown), mealybugs, and leafhoppers. The species included in the test were: *Colocasia esculenta, Alocasia macrorrhiza, Cyrtosperman chamissonis, Colocasia gigantea, Philodendron* sp., *Amorphophallus campanulatus, Scindapsus* sp., *Diffenbachis* sp., *Aglaonema* sp., *Caladium x hortulanum, Monstera deliciosa, Xanthosoma sagittifolium*, and two other nonaroid species: *Crocus* and *Ipomoea batatas* (sweet potato). The non-aroid species were used as a control for distinguishing symptoms caused by the insects from those caused by the virus.

The experiment was planted on May 11, 1992. Each plant species was planted in a separate, medium-size, plastic bag inside each of the nine cages (usually 2-5 plants per bag, depending on plant size).

The source virus plants (i.e., taro plants showing the Bobone symptoms) were placed inside each cage together with the vectors. To ensure randomization of the disease spread, the source plants together with the vectors were randomly moved from one cage to another.

Results and Discussion

Testing of Young Seedlings for ABVC Resistance

After the removal of the insects (vectors), the seedlings recovered from the insect damage and started to develop very specific symptoms. Seedling plants were not exposed for a long time to the vectors. The vectors which infested the seedlings were predominantly aphids. *Tarophagus proserpina*, the taro leafhopper remained more or less on source plants, which were bigger and more suitable for them. Aphids moved slowly. Once they came on the seedlings, they started to produce colonies.

The symptoms were fully developed about three weeks after elimination of the insects. The number of healthy plants was decreasing rapidly (Tables 1 and 2). The lowest number of healthy plants was estimated on May 20, 1992 (almost three months after planting). Only 2.9 percent of the plants were not affected. After that, plants started to recover slowly.

The dynamics of the development of the disease on young seedlings were similar to the dynamics in the field conditions where mature plants were studied. The systemization of symptoms was probably the biggest difficulty. At first, the symptoms were classified into seven groups (Table 3). This classification, however, was not sufficient because there were many types of symptoms that did not belong to any of the groups. The symptoms were classified once more into 21 groups (Fig. 1). This

Table 1. The development of Bobone symptoms on young taro seedlings on April 27, 1992.

	CROSS																	
Rep	1		2		3		4		5		6		7		8		9	
	9 a	2 b	3	0	3	1	1	0	0	0	2	2	2	1	0	0	4	2
1	10 c		10		10		10		10		10		10		9		9	
	2	0	3	0	3	2	2	0	1	1	2	2	5	4	0	0	5	3
2	5		6		10		10		5		10		10		8		10	
	3	0	3	1	4	3	6	3	3	0	2	1	4	2	5	2	3	1
3	9		10		10		9		7		10		8		9		9	
	3	0	4	0	1	0	2	1	6	3	1	1	2	0	3	0	2	1
4	7		8		4		7		10		8		9		9		7	
	2	1	4	0	2	0	2	0	5	3	7	1	3	2	6	3	4	2
5	7		5		6		7		9		9		8		9		8	
	2	0	4	0	3	0	2	0	1	0	3	0	1	0	3	0	4	3
6	8		6		3		8		9		8		9		9		9	
	0	0	5	0	4	0	2	2	1	0	5	1	2	0	4	1	2	1
7	4		10		5		9		9		8		9		8		4	
	7	2	7	2	4	2	4	3	2	0	3	3	4	0	6	1	4	1
8	9		10		10		9		10		4		10		8		9	
	3	1	4	3	2	0	3	2	4	0	3	1	1	0	4	1	2	1
9	9		8		6		8		9		10		6		9		10	
	31		37		26		24		23		28		24		31		30	
SUMMARY	68		73		64		77		78		77		79		78		75	

(TOTAL) percentage of healthy plants ----62.03%

a = total number of plants with Bobone symptoms; b = severe symptoms of Bobone; c = total number of plants per pot

Table 2. The development of Bobone symptoms on young taro seedlings on May 20, 1992.

	CROSS																	
REP	1		2		3		4		5		6		7		8		9	
	0 a	1 b	0	1	0	1	1	0	0	1	0	1	0	1	0	0	0	2
1	10 c		10		10		10		10		10		9		9		9	
	1	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0
2	5		6		9		10		5		10		10		8		10	
	1	0	0	1	1	1	0	0	2	0	0	0	0	0	0	0	0	2
3	9		10		9		9		7		10		8		9		9	
	0	1	0	0	0	0	0	2	1	2	0	1	0	1	0	2	0	0
4	7		7		4		7		10		8		9		9		7	
	0	0	0	0	0	1	0	1	0	0	2	2	0	3	0	1	0	0
5	6		5		6		7		9		9		8		9		8	
	1	0	1	2	0	2	2	2	1	0	0	0	0	2	0	1	0	0
6	8		6		3		7		9		8		9		8		9	
	1	4	0	2	0	0	0	2	0	1	0	0	0	2	0	3	1	1
7	4		9		5		9		9		8		8		8		4	
	1	1	1	1	0	2	0	1	0	0	0	0	0	3	0	3	0	0
8	8		9		9		9		10		4		10		8		9	
	0	1	0	0	0	2	0	1	0	2	0	0	0	0	0	0	0	1
9	9		8		5		8		9		9		6		9		9	
	5	66	2	70	2	60	3	76	4	78	2	76	0	77	0	77	1	74
SUMMARY	7.6%		2,8%		3.3%		3.9%		5,1		2.6%		0%		0%		1.3%	

(TOTAL) Percentage of healthy plants ----2,9%

a = total number of healthy plants; b = plants with severe Bobone symptoms; c = total number of plants per pot

Table 3. Description of symptoms

REPLICATION	1	2	3	4	5	6	7	8	9
1	3d 3e 10*	1 (f+g) 10	1d 10	1d 10	1g 10	1f 1e 10	2a 1d 10	2d 1g 9	2e 2d 9
2	1g 1d 5	(d+c) 2e 6	3e 2g 10	1e 2d 1 10	1e 5	1f 2e 10	1(a+g) 1(g+f) 1(c+d) 10	1f (g+e) 8	5e 1(a+e) 10
3	1g 1(a+g) 1e 9	3e 3d 10	1y,1f 2a 1(a+g) 10	1(g+e) 1e 9	1(g+e), 1g 1a 1c 7	1 (a+f+g) 1(f+e) 1e, 1g 10	1(a+f), 1a 1g,1b 1(g+e) 8	1a 1(n+g) e(a+g) 9	1(b+f) 2a 1b 9
4	1(a+e) 1(a+d) 1(a+b+e) 7	1a 1(a+f+g) 1(e+f) 8	1(e+g) 1b 1(a+b) 1d 4	1(e+g) 1b 1(f+g) 1(f+d) 7	2(a+e) 1(d+g) 1d, 1b 10	1f 1(f+g) 8	1(a+g) 1(a+g+f) 1(b+d) 9	1e 2y 9	1e 1(d+g) 1(c+f) 7
5	1e 1(c+f) 1f 6	2a 1e 1(a+g) 5	1(a+f+g) 1a 1(a+e) 6	1(d+f) 1(a+g) 1e, 1d 7	3(a+e) 1(e+g) 1e, 1b 9	3a 2b 2(a+e) 9	3a 1e 1e 8	1c 1g 1(f+g) 9	3a 1f 1(e+g) 8
6	1(a+g) 1e 8	1g 1f 6	1(g+a) 1d 3	1(g+a) 1(g+f) 1d 8	1a 1b 1d 9	1b 1d 1(a+c) 8	1e 2a 1(a+g) 9	3b 1(b+e) 8	5e 1a 9
7	1e 1b 4	1(a+e) 1e,1a 1(e+f) 10	1a 1e 5	1b 1(d+g) 9	1(a+g) 1(g+e) 9	1a,1g 1(b+d) 1(a+e) 8	1(a+g) 1(a+d) 1b 9	1a 1b 8	1a 1b 4
8	9(a+e) 5e 1d 9	9e 1d 1b 10	1(a+e) 4e, 1d 1(e+g) 10	2(a+e) 1(a+g) 2d 9	1a,3e 1(f+g) 2d 10	1e,1d 1(a+e) 1a 4	2(a+e) if, 2d 1e 10	1(a+e) 2d 8	2e 2d 9
9	1(a+e) 1(a+c) 1d 9	2a 4e 1d 8	1(a+e) 2e 6	1(a+b+c) 5e 8	1(a+b) 2e 9	1(a+g) 1a 1(e+g) 10	2e 1(a+d+g) 1d 6	5e 1d 9	1(a+e+g) 1b 2d 10

Key:

a. elongated leaf
b. white vein chlorosis
c. yellow vein chlorosis
d. lineal deformations
e. strongly deformed leaf with thick petiole
f. yellowish lesions on leaf lamina
g. white lesions on leaf lamina
* total number of plants

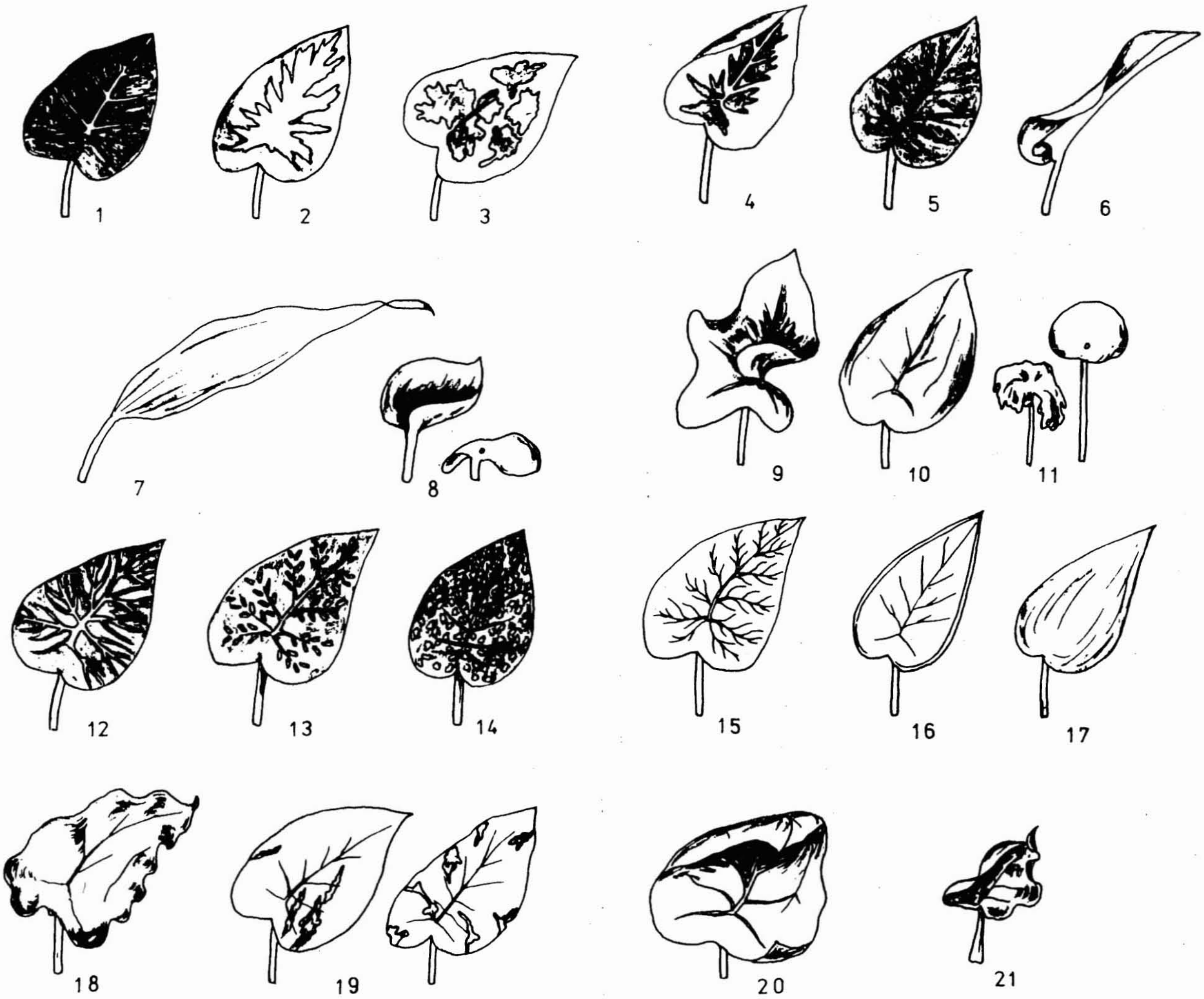

Fig. 1. Different symptoms on young taro hybrids exposed to virus transmission inside cages with different Bobone sources and vectors *Tarophagus*, aphids).

1. Extremely strong, prounced veins on silvery-green leaf blade
2. Light grey-green central part, surrounded by normal dark green
3. Extremely dark green lesions/blotches on light silvery-green blade
4. Extremely dark green areas in center disconnected by veins, light green blade, smaller and partly folded leaf
5. Normal green blade with almost white fern-like lesions between veins
6. Silvery-green, elongated, rolled blade
7. Extremely elongated, silvery-green blade with almost invisible veins
8. Round thick blade curved upward or downward, without big deformations on lamina surface
9. Deformed leaf
10. Leaf blade with lineal deformation
11. Very young leaves--one with extreme deformation of the blade (curved downward), the other with almost circular blade
12. Leaf blade with yellow or white necrosis of vein
13. Yellow, necrotic, elongated spots placed in regular way on either sides of veins
14. Yellow or whitish necrotic spots on blade
15. Very clear dark veins on light yellow blade
16. White-grey-green elongated lamina with clearly visible vascular system
17. Lamina where vascular system cannot be distinguished
18. Curved and deformed leaf
19. Elongated yellow lesions with yellow edge
20. Deformed short leaf curved upward
21. Young deformed leaf with very strong and thick petiole

classification was not totally adequate, but it was satisfactory. The symptoms were not equally stable. Some of them disappeared very fast and plants remained without them. Some of the symptoms developed into more complex types.

Concerning the difference in resistance level among different crosses, it was not possible to make any clear conclusions. During the period of five months, the situation changed drastically, favoring different crosses at different times. Plants in very early stages of growth are probably too sensitive to ABVC to be studied for the differences in resistance level.

Testing Other Aroid Species for Resistance to ABVC in Controlled Conditions

The most preferable species for taro leafhoppers was obviously taro (*Colocasia esculenta*) (Table 4). The most desired species for green aphids was *Alocasia macrorrhiza* and for brown aphids *Caladium* (Table.4).

The first clear symptoms appeared on *Colocasia esculenta, Alocasia macrorrhiza, Colocasia gigantea*, and *Cyrtosperma.* The strongest effects were observed on *Colocasia esculenta, Cyrtosperma, Colocasia gigantea*, and *Alocasia macrorrhiza*. On August 11, 1992 (three months after planting), all studied aroid species were affected except *Philodendron, Aglaonema,* and *Monstera* (Table 4).

The interspecific cross *Colocasia esculenta* x *Colocasia gigantea*, which was tested separately, also showed the symptoms of ABVC.

Conclusions

The test of young seedlings for ABVC in controlled conditions can be efficiently used in taro breeding. The seedlings, however, should not be too young. Thesymptoms of the virus complex are developing in a specific way on young seedlings. It is possible that the virus complex splits into its components. The diversity of symptoms could be an indication of the complexity of the virus structure, and this could be more complicated than originally thought. More virus particles or variations within existing particles could be involved. Studies of ABVC structure have to involve plant geneticists, breeders, and virologists of different specialties.

Other aroid species (especially aroid root crops) can be easily affected by ABVC. In favorable natural conditions, the majority of the aroid species (except *Colocasia esculenta*) are more resistant to ABVC. The main reason is probably the resistance to the vectors of the disease spread. In controlled conditions several species can be affected by the disease spread. In controlled conditions inside cages with dense populations of vectors of the disease spread, the plants can be affected by the disease easily.

Table 4. Spread of Alomae-Bobone virus complex vectors (February 6, 1992).

	Replications								
	1	2	3	4	5	6	7	8	9
Colocasia esculenta	L	L,GA	L,GA	L,GA	L,GA	L,GA	L,GA	L,GA	L,GA*
Alocasia macrorrhiza		GA	L,GA	GA,BA		BA	BA	GA	BA*
Cyrtosperma		M	GA	M,BA		L			L*
Colocasia gigantea			GA	BA		L			L*
Philodendron					L				
Amorphophallus	L				GA				*
Scindapsus		L						L	L*
Dieffenbachia						GA			GA*
Aglaonema									
Caladium	L	BA	BA	GA,BA	BA	BA		BA	BA*
Monstera							L	L	
Xanthosoma			L	GA	BA,GA				GA*
Crocus				L					
Sweet potato							M, L	A	M

Key: BA = brown aphics; GA = green aphids; L = leafhoppers; M = mealybugs; * = species affected by ABVC

Summary

The breeding for resistance/tolerance to ABVC is based on testing large populations in field conditions. Expensive field testing cannot be replaced but can be accompanied by the testing of young seedlings. Very young seedlings are too sensitive for the testing. The symptoms of Bobone appear very fast on young plants. They are not uniform. The diversity of symptoms indicates that the ABVC structure could be more complicated.

Other aroid crop species are usually not affected by ABVC in normal or favorable environmental conditions. Inside controlled conditions, the majority of them do not show any special resistance to the disease. They probably possess tolerance of the vector.

References Cited

Gollifer, D. E., G. V. H. Jackson, A. J. Dabek, R. T. Plumb & Y. Y. May. 1975. Taro viruses in the Solomon Islands: Symptoms and transmission. *In* Proc. Regional Meeting on the Production of Root Crops. Suva, Fiji. Technical Paper 174: 114-117.

Gollifer, D. E., G. V. H. Jackson, A. J. Dabek, R. T. Plumb & Y. Y. May. 1977. The occurrence and transmission of viruses of edible aroids in the Solomon Islands and the South West Pacific. PANS 23(2): 171-177.

Gollifer, D. E., G. V. H. Jackson, A. J. Dabek & R. T. Plumb. 1978. Incidence, and effects on yield, of virus diseases of taro *(Colocasia esculenta)* in the Solomon Islands. Ann. Appl. Biol. 88: 131-135.

Jackson, G. V. H. & D. E. Gollifer. 1975. Disease and pest problems of taro *(Colocasia esculenta* L. Schott) in the British Solomon Islands. PANS, Vol. 21, No.1.

James, Mari, R. T. Kenton & R. D. Woods. 1973. Virus-like particles associated with two diseases of *Colocasia esculenta* (L.) Schott in the Solomon Islands. J. Gen. Virology 21: 145-153.

Kenton, R. H. & R. D. Woods. 1973. Viruses of *Colocasia esculenta* and *Xanthosoma sagittifolium*. Pest Articles and News Summaries 19: 38-41.

Zettler, F. M. 1986. Dasheen mosaic virus and its control in cultivated aroids, p. 91-100. *In* Plant Virus Diseases of Horticultural Crops in the Tropics and Subtropics. Food and Fertilizer Technology Centre for Asia and Pacific Region, Taiwan, Republic of China.

[1] Director of Research

[2] Research Officer (Plant Breeding)

[3] Research Officer (Plant Protection), Ministry of Agriculture and Lands, Dodo Creek Research Station, P.O. Box G13, Honiara, Solomon Islands

The Editor

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